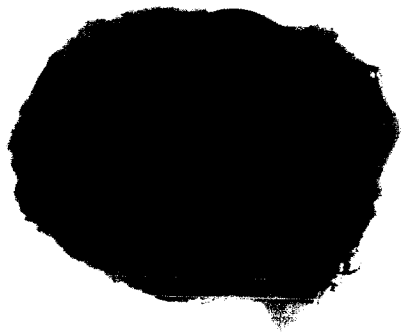
BOEING



SEATTLE, WASHINGTON

BOEING AIRPLANE COMPANY
SEATTLE 24, WASHINGTON

DOCUMENT NO D2-35167

UNCLASSIFIED TITLE Installation of Solar Cells On Photovoltaic Concentrating Panels

MODEL NO Research CONTRACT NO JPL 950270 - NAS 7-100

ISSUE NO ISSUED TO

CLASSIFIED TITLE
(STATE CLASSIFICATION)

WORK ORDER NO PAGE NO ITEM NO

SPECIAL LIMITATIONS ON ASTIA DISTRIBUTION

ASTIA may distribute this report to requesting agencies subject to their security agreement, approved fields of interest, and the following:

_ UNLIMITED—To all agencies of the Department of Defense and their contractors.

X LIMITED—To U. S. Military organizations only.

This report may be distributed to nonmilitary agencies not approved above subject to BAC approval of each request.

NOTE: the LIMITED category may be checked only because of a current or potential patent, proprietary, ethical, or similar implications.

This Document has been released to the following government agencies:

1. Defense Documentation Center

A. E. White 8/2/63
A. E. White
Manufacturing

PREPARED BY J. E. Anderson 8-2-63
J. E. Anderson

SUPERVISED BY J. F. Balsch 8/2/63
J. F. Balsch

APPROVED BY R. A. Anderson 8/2/63
R. A. Anderson

CLASS & DISTR APPROVED BY G. E. Hughes 8-2-63
G. E. Hughes (DATE)

J. E. Krezak
Quality Control

K. E. Arnold for
K. E. Arnold
Materiel

NO. OF PAGES 45 (EXCLUDING TITLE AND REVISION AND ADDITION PAGES.)

DOCUMENT TITLE PAGE

BAC 324 B-R8

2-7-00

TABLE OF CONTENTS

ACTIVE PAGE RECORD

SECTION	ORIG REL PAGE NO.	REV SYM	ADDED PAGES						SECTION	ORIG REL PAGE NO.	REV SYM	ADDED PAGES					
			PAGE NO.	REV SYM	PAGE NO.	REV SYM	PAGE NO.	REV SYM				PAGE NO.	REV SYM	PAGE NO.	REV SYM	PAGE NO.	REV SYM
	1																
	2																
	3																
	4																
	5																
	6																
	7																
	8																
	9																
	10																
	11																
	12																
	13																
	14																
	15																
	16																
	17																
	18																
	19																
	20																
	21																
	22																
	23																
	24																
	25																
	26																
	27																
	28																
	29																
	30																
	31																
	32																
	33																
	34																
	35																
	36																
	37																
	38																
	39																
	40																
	41																
	42																
	43																
	44																
	45																

1.0 SCOPE

This document describes the requirements and procedures for the fabrication of the concentrating photovoltaic panels awarded under Contract (950270) by the Jet Propulsion Laboratory, California Institute of Technology, and sponsored by the National Aeronautics and Space Administration under Prime Contract (NAS 7-100.)

2.0 REFERENCES

The following publications, of the issue in effect on the date of use, shall form a part of this document to the extent specified herein:

2.1 Military

MIL-W-16878C Wire, Electrical, Insulated, High Temperature

2.2 The Boeing Company

a. BAC 5432 Casting and Potting with Resins

b. BAC 5703 Criteria for Limited Contamination Areas

c. BAC 5770 Cleaning, Descaling and Surface Preparation of Copper and Copper Alloys

d. Document No. D2-35241 Process Document for Bright Anodizing of Solar Cell Reflectors

2.3 Jet Propulsion Laboratory

a. 20014F General Specification, Soldering Process

b. 20016 General Specification, Workmanship

c. 30804A Test Specification - Mariner Flight Equipment Power Supply System, Solar Panel Assembly

d. 30266/019 Process Specification, Spacecraft Flight Equipment, Mark IV Solar Panel, Electrical Continuity Check of Solar Panel

3.0 MATERIALS

3.1 Adhesives and Encapsulants

a. RTV 40 Silicone Adhesive with Thermolite 12 Catalyst

General Electric Company
Silicone Products Division
Waterford, New York

b. LTV 602 Silicone Encapsulant with Catalyst SRC-05

General Electric Company
Silicone Products Division
Waterford, New York

c. X-1140, a pressure sensitive thermal setting adhesive on a paper carrier

Minnesota Mining and Manufacturing Company
St. Paul, Minnesota

3.2 Electrical Tape

a. Electrical Tape No. 67, Thermosetting, 5 mil

Minnesota Mining and Manufacturing Company
St. Paul, Minnesota

3.3 Metal Clad, Laminated Plastic Sheet

a. Micaply copper clad laminate, EG752-T

Micaply Corporation
Los Angeles, California

3.4 Solvents

a. Ethyl alcohol, Reagent Grade

b. Methyl Ethyl Ketone (MEK), Reagent Grade

3.5 Balance

a. Ohaus Triple-Beam, or equivalent, 2610 gram capacity. Sensitive to 0.1 gram.

3.6 Solar Cells

The solar cells will be procured, inspected, and graded by JPL and then delivered to The Boeing Company.

3.7 Glass Filters

The glass filters will be procured and inspected by JPL and then delivered to The Boeing Company.

3.8 Primer

a. PR-1902

Products Research Company
Los Angeles 39, California

3.9 Solder

a. Solder, energized rosin-core, 63/37 eutectic, alpha metals cen-tri-core or other engineering approved equivalent.

b. Solder, bar, 63/37 eutectic high purity, alpha metals vaculoy or other engineering approved equivalent.

3.10 Grommet

Machined from nylon rod or tube.

3.11 Connector Tabs

a. Beryllium copper, 0.002 inch thick

3.12 Flux

a. Type "A" per MIL-F-14256 (Divco 300 or other engineering approved equivalent).

4.0 QUALITY ASSURANCE

4.1 Process Control

a. All processes shall be performed in accordance with the requirements of this document.

b. All processes shall be subject to approval and inspection by Engineering and Engineering decisions shall be final.

4.2 Parts Inspection

a. All component parts and assemblies shall be subject to Quality Control inspection and acceptance. Rejected materials shall be subject to review by the responsible engineering unit. Engineering decisions shall be final.

b. All finished assemblies shall be inspected for defects and discontinuities.

4.3 Environmental Control

The Quality Control Department shall periodically check the assembly area for conformance to the requirements of BAC 5703 for Class M environment.

5.0 HANDLING PROCEDURES

5.1 Concentrating Panel

a. Storage

Inspected and approved optical quality submodules shall be packaged bare and shipped in a wooden box. The submodule shall be stored in the box until required for cell installation.

b. Cell Installation

Remove the submodule from the box by grasping the edges of the center trough and place the submodule on a supporting fixture. Either white cotton gloves or finger cots shall be worn during all handling of the submodule. Great care shall be exercised to avoid contacting the reflecting surfaces or the stiffeners in the back of the submodule or in any way deforming the structure.

Avoid contacting the unprotected reflective surfaces with tools, unprotected fingers, or any objects that may cause damage to the reflectors. No rings shall be worn during any processing operations.

Any portion of the submodules not being worked on shall be covered to protect against dust and accidental damage.

c. Cleaning

After cells have been installed, the reflecting surfaces shall be cleaned by dipping either cleaning tissue or cotton "Q" tips in ethyl alcohol and gently wiping. Immediately remove any ethyl alcohol that may come in contact with the cells. Under no circumstances permit ethyl alcohol to stand for an extended period on the cells or in the crevices between the cells.

5.2 Solar Cells

a. Accountability

The cells shall be logged in and stored in a locked cabinet. Cells will be released by supervision to the installing personnel as required, and a record shall be kept of all quantities issued. All cell breakage shall be recorded. Unused cells and filter glasses shall be returned to engineering for return to JPL.

b. Storage

Store the cells at all times in plastic solar-cell trays, except when the cells are being tested and installed in the submodule. Special cabinets must be supplied when the cells are being tested for group ratings. If for some reason a portion of the cells are removed from the original tray, the removed cells shall be placed in solar-cell trays which shall be identified with the same current rating, voltage, and lot number that appears on the original container. Care shall be taken to prevent mixing of cells having different ratings.

c. Handling

All personnel handling solar cells shall wear clean finger cots on at least the thumb, fore and middle finger of both hands. The cots shall be washed with ethyl alcohol to remove residues that may have been transferred to the cot by accidental contact with uncovered skin or hair. The finger cots shall be discarded after removal. The cells shall at no time be handled with uncovered fingers and no rings shall be worn during any of the processing operations.

d. Inspection

Visually inspect each cell for defects prior to mounting. Examine both surfaces of the cell carefully for defects such as cracks, defective solder strips, etc.

5.3 Adhesives and Primer

a. LTV-602

Uncatalyzed LTV-602 shall be stored in 100-200 gram covered containers, at a temperature of 32-38°F. To minimize moisture condensation, the container must be allowed to come to room temperature prior to opening.

b. RTV-40

Uncatalyzed RTV-40 shall be stored in 100-200 cc. covered containers maintained at a minimum temperature of 0°F. To minimize moisture condensation, the containers must be allowed to come to room temperature prior to opening.

c. PR-1902 (BMS 5-62) Primer

The primer shall be stored in its original sealed or unopened container. The shelf life is as follows:

90°F maximum	30 days from date received
70 ± 5°F	60 days from date received
45 ± 5°F	120 days from date received

5.4 Tapes

a. 3M No. 67 Electrical Tape

The tape shall be stored in a protective wrapping at room temperature. Upon removal of the tape from the package, care shall be exercised not to contaminate the edges or the surfaces. Under no circumstances shall the adhesive side of the tape be touched during installation.

b. X-1140 Pressure Sensitive Tape

The tape shall be stored at room temperature in its original package. Under no circumstances shall the tacky sides of the tape be touched during installation.

6.0 ENGINEERING REQUIREMENTS

a. Solar cells are to be bonded to and insulated from the solar concentrator with a thin layer of dielectric adhesive which is capable of withstanding an occasional repair operation such as might occur in resoldering a terminal to an individual solar cell.

b. The assembled panel shall be capable of withstanding the radiant heat and extreme cold of space environment for an extended period.

c. The panel shall be capable of meeting the Type Approval Test requirements specified in JPL specification 30804A.

7.0 FACILITIES CONTROL

The following requirements apply to the facilities used in the assembly operations.

a. All assembly operations shall be performed in an area conforming to the environmental requirements of BAC 5703, Class M.

b. A vacuum chamber shall be capable of developing a minimum pressure of 29.0 inches of mercury, gauge.

c. Air circulating ovens shall be controllable to $\pm$ 5°F at 250°F.

d. The solar cell soldering fixture shall be capable of holding two solar cells firmly but gently in place and indexing the cell connectors.

e. The vacuum-chuck holding and indexing fixture shall be capable of holding 43 pairs of matched solar cells held firmly but gently in place, and indexing each assembly of cells for soldering into strips.

f. A controlled temperature soldering iron shall be used for all soldering operations involving the joining of the "P" layer of the solar cells to the cell connectors.

8.0 MANUFACTURING

8.1 Summary

a. Fabrication operations shall be performed in the order shown in Figure 1. Operations shown in parallel may be performed in parallel, and operations shown in series shall be performed in series.

b. A total of 43 pairs of matched solar cells shall be soldered into a single strip which will be flat-mounted in the trough of the concentrating submodule.

c. Two matched solar cells will be selected and held in pairs on a vacuum-chuck holding fixture that will index the connector to the paired cells. The cell-connector will then be soldered to the positive terminal of the paired cells.

d. The paired cells are now ready for the bonding of the glass filters to the cells. Each pair of cells is held in a holding fixture with the dark blue, light sensitive side of the cells in the up position.

e. A thin bead of LTV 602 resin is carefully applied centrally and longitudinally down the center of the face of each cell. Using vacuum tweezers, or plastic tipped tweezers, the glass filter is properly oriented so that the mitered edge is in the upper left hand corner as viewed with the "P" strip away from the operator.

f. The paired cells are then cured at room temperature for 36 hours minimum prior to applying the PR-1902 primer.

g. After the glass filters have been partially cured, the paired cells are visually inspected for air bubbles. Unaccepted cells are repaired.

h. Test all pairs and group according to the current rating as specified by Engineering.

i. Select a cell pair having the required current rating as specified by the placement diagram. The pair is then placed, filter glass side down, on a vacuum chuck holding and locating fixture of sufficient length to hold all the cells required for a single trough of the concentrating submodule.

j. After the first pair of each strip has been properly located on the holding fixture, each successive pair is selected, indexed, and soldered to the preceding pair of cells. Each joint is cleaned with ethyl alcohol.

k. Insert the completed strip and index to the strip test fixture.

l. Remove the strip assembly tool and electrically test each pair of cells for degradation by use of the test console.

m. After degradation tests have been completed, relocate assembled cells on the strip assembly tool.

n. While the strip of cells is still on the holding fixture, a thorough visual inspection of the solder joints is made.

o. The back (silver colored) sides of the cells are primed with one continuous coat of PR-1902 primer 60 minutes prior to the installation in the trough of the concentrating submodule.

p. A strip of Electrical Tape No. 67 is applied to the MEK cleaned surface of the trough of the concentrating submodule.

q. The bus bars are cleaned with MEK. A strip of X-1140 adhesive is applied to the faying surfaces of the bus bars. The bus bars are assembled to the stiffeners and held in place by clamps.

r. The concentrating submodule is placed in an air-circulating oven and the adhesive cured for 3 hours at 250 $\pm$ 5°F.

s. Cut wiring access holes and install nylon grommets. Lock the grommets in place by hot forming.

t. The exposed surface of the Electrical Tape is cleaned with MEK and one continuous coat of PR-1902 primer is applied. A second coat of PR-1902 primer may be applied if the first coat is not continuous. The primer is air dried a minimum of 60 minutes prior to the application of the RTV 40 adhesive.

u. RTV 40 adhesive is applied to the primed surface of the electrical tape. The solar cell strips are indexed in each trough of the concentrating submodule.

v. The RTV 40 is partially cured for two hours.

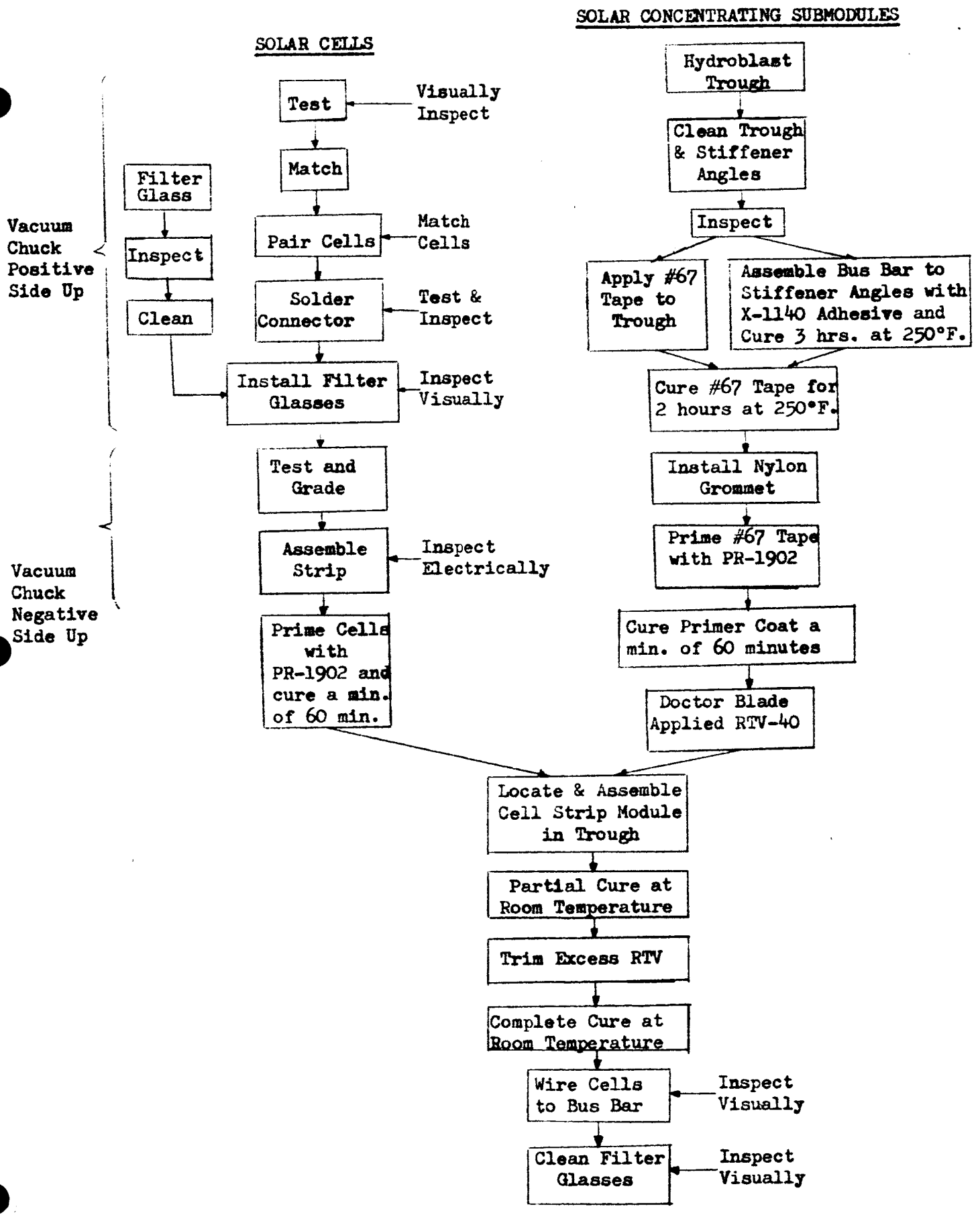
w. Excess RTV 40 is trimmed from the submodule with a plastic knife.

x. The cure of the RTV 40 is complete after 48 hours at room temperature.

y. Solar-cell connectors are soldered to the bus bars.

z. The exposed surfaces of the filter glass and reflectors are cleaned with ethyl alcohol.

aa. Each completed submodule is inspected visually and electrically.



FABRICATION FLOW CHART

FIGURE 1

8.2 Installation of Paralleling Bus Bar

The paralleling bus bar consists of a pre-assembled tinned copper strip and insulation. The paralleling busses are installed on the stiffeners in the following manner:

a. Clean the stiffeners on both sides with MEK, using cotton swabs. Wipe the stiffeners with tissue. Continue this process until no residue is visible on the tissue.

b. Clean the bus bar by wiping the non-copper-tinned surface with MEK and cotton swabs. Wipe the bus bar with tissue. Continue this process until no residue is visible on the tissue.

c. Cut a strip of X-1140 adhesive and press the adhesive side to the back side of the bus bar and remove the protective paper from the back side of the adhesive.

d. Place the bus bar against the stiffener and press firmly into place.

e. Apply pressure to the bus by means of a special holding tool and cure the adhesive for 3 hours at 250 $\pm$ 5°F.

8.3 Fabrication and Installation of Solar Cell Connectors

8.3.1 Fabrication

a. Clean the beryllium-copper sheet in accordance with BAC 5770.

b. Blank out the connectors in such a manner that the tab is parallel to the rolling grain.

c. Dip coat the cleaned beryllium-copper sheet with solder, on the solder areas only, and wipe with a soldering iron to a 1 to 2 mil thickness of solder.

d. Form the connectors in accordance with the Engineering drawing.

8.3.2 Installation

a. For a given position, refer to the placement diagram card and select the cell pair from the appropriate group.

b. Index the matched cells on the vacuum holding fixture with the dark blue, light sensitive side up. Open the vacuum valve on the side of the holding fixture so as to hold the cell firmly but gently in place.

c. Index the other matched cells to the other side of the holding fixture in the same manner as above and lock in place with vacuum.

d. Index the connector between the spring pressure block and the holding fixture.

e. Apply a thin film of flux to the positive termination solder strip of each cell.

f. Locate the pretinned beryllium copper connector in the soldering fixture with the contact tabs in contact with the fluxed solder strip on the cell.

g. Using the temperature controlled soldering iron, solder the 4 connector contact tabs to the 2 solar cell solder strips. The tip of the soldering iron should be held in firm contact with the connector tab a minimum of 4 seconds and a maximum of 6 seconds, to ensure melting and flow of the solder at the joint.

OPTION: Resistance soldering may be used in lieu of the hand soldering, subject to approval by the responsible engineering unit.

h. Clean the solder joint with ethyl alcohol.

i. Release the vacuum. GENTLY remove the matched pair of cells with vacuum tweezers or plastic tipped tweezers.

j. Assembled pairs shall be electrically tested at a rate of eighty pairs per working day based on normal production. Test results shall be statistically analyzed by Quality Control and appropriate reports submitted on a daily basis to the responsible engineering unit.

8.4 Installation of Glass Filters

8.4.1 Cleaning

a. Clean finger cots or plastic tipped tweezers must be used when handling glass filters or paired solar cells.

b. Clean both sides of the glass filters and the faces of the solar cells with clean cotton swabs saturated with MEK.

c. Dry with clean, untreated lens tissue. Drying must be accomplished under a lamp so that any smudges can be seen readily.

NOTE: While drying the glass filter, visually inspect it for scratches, chips, ragged edges, discoloration, and any other imperfections. Imperfect filters shall be placed in a reject container for return to JPL.

d. One corner of each filter has been mitered for orientation purposes. Place the cleaned filters on the "P" side of the cell with the mitered corner in the upper left-hand corner as viewed with the "P" strip away from the operator.

8.4.2 Preparation of Adhesive and Installation of Glass Filters

a. Thoroughly blend 30 grams of LTV 602 resin with 0.09 grams (0.30 percent by weight) of SRC-05 catalyst in accordance with the procedures in BAC 5432. Deaerate in accordance with the procedures in BAC 5432.

b. Locate the paired cell assemblies on the cover glass vacuum holding fixture and lock into place with vacuum.

c. Apply a bead of the blended LTV 602 centrally and longitudinally down the center of the face of each cell.

d. Gently pick up each glass filter with vacuum or plastic tipped tweezers and place it on a solar cell, with the mitered corner in the upper left-hand corner of the cell as viewed with the "P" strip away from the operator in such a manner that the resin spreads out over the solar cell surface with a minimum of voids or bubbles.

1. When air pockets cannot be worked out easily, gently lift the filter glass off the cell with a plastic blade or swab stick and remove the air bubbles.

2. In some instances, it may be necessary to remove the filter glass and add adhesive if an adequate amount of adhesive was not applied to the cell.

e. Make sure the filters are aligned properly with each cell. Check for alignment and realign as required.

f. Approximately 1 to 2 hours will elapse before the filters are securely set for curing. During this time, check the filters at approximately 15-minute intervals for slippage. Realign slipped filters.

8.4.3 Curing the Adhesive

a. Cure the adhesive at room temperature for a minimum of 36 hours before applying the PR-1902 primer.

b. Visually inspect the filter glasses and replace as required.

c. Electrically test all cell pairs and group according to the current rating as specified by engineering.

8.5 Soldering Cells into Series Strips

a. Index and lock the first pair of cells on the soft cushioned surface of the vacuum holding fixture with the back (silver colored) side up.

b. Index and lock the second pair of cells to the vacuum holding fixture as above. The connector tab will overlap the solder tinned negative surfaces of the adjacent cells when located in the holding fixture.

c. Apply a film of flux between the connector tab and the tinned surface of the cells and solder the connector tab to the cells. The tapered, flat surface of the soldering iron should be brought into contact with the connector tab at one side and held until the solder begins to melt. As the solder melts, slowly wipe the tip of the iron across the tab to the opposite side, melting the solder on the tab and the cell as the iron is moved. To prevent crazing of LTV-602, do not attempt to resolder a tab while the tab is still hot.

d. Clean the solder joint with ethyl alcohol. Visually inspect.

e. Repeat items (b) through (d) for each successive pair of cells until all pairs required for the strip have been soldered in place.

f. Insert the completed strip and index to the optic strip test tool.

g. Release the vacuum on the holding fixture.

h. Remove the strip assembly tool and inspect the faces of the cells for damage.

i. Electrically test each pair of cells in the series strip and record the power output.

j. Repair or replace any cells degradated during the soldering process.

k. Acceptable series strips will be reindexed to the holding fixture and locked in place with the back side up.

8.6 Installation of Insulating Tape in Troughs of Concentrating Submodule

a. Thoroughly clean the troughs of the submodule by swabbing with cotton dipped in MEK.

b. Apply a 7/8-inch wide strip of No. 67 Electrical Tape to the trough and bottom edges of the reflectors. Carefully center the tape so that equal widths of the tape are on each side of the reflector.

c. Work out any entrapped air and press all areas of the tape into contact with the trough. The tape should lie smoothly in the trough and be free of wrinkles and air bubbles.

d. Using a plastic tool, force the tape into the bend line between the trough and the reflector.

e. Place the submodule in an oven at a temperature of 250 ± 5°F.

f. After 30 minutes have elapsed, remove the submodule from the oven and again force the tape into the bend lines. Return the submodule to the oven and cure for 2½ hours at 250° ± 5°F.

g. Remove the submodule from the oven and remove the tape from the wiring access holes.

8.7 Insulation of Wiring Access Holes

a. Gently press nylon grommets into place from the reflector side.

b. Invert the submodule and mold the nylon grommets into place with the hot forming tool held at a temperature of 400°F.

8.8 Installation of Prewired Series String in Trough

a. Clean both the backside of the cells and the taped surface of the trough by swabbing with cotton swabs dipped in MEK. Take care not to contact the reflecting surfaces of the submodule. Prime the bonding surfaces with one continuous coat of PR-1902 silicone primer. Allow the PR-1902 primer to dry for a minimum of 60 minutes.

NOTE: Do not apply PR-1902 primer to cells until the LTV-602 cover glass adhesive has completely cured for 36 hours. A second coat of PR-1902 primer may be applied to the electrical tape if the first coat is not continuous.

b. Weigh 50 grams of RTV-40 into an open container. Using a dropper, add 0.5 grams of Thermolite 12 catalyst to the RTV-40 and mix thoroughly. Place the container in a vacuum chamber and deaerate for a minimum of five minutes with a vacuum of 29 inches of mercury. Remove the container from the chamber and fill the applicator. Adjust applicator and lay an 8 mil minimum thickness of RTV-40 in the trough.

c. Grasp the vacuum carrying fixture with the cells, invert, and carefully lay the cells in the trough. Assure that the erected tabs of the cell connectors properly enter the wiring holes. Release the vacuum and remove the fixture from the cells. Inspect and position each cell. After all troughs have been filled, gently place weights on the cells, and place the submodule in a vacuum chamber. Evacuate to 29 inches of mercury and hold at pressure for 5 minutes. Remove and allow the submodule to cure for two hours at room temperature.

d. After curing for a minimum of two hours, clean the excess RTV-40 from the area between the cells and reflectors and from between adjacent cells. Use either plastic knives or sharpened toothpicks. Metallic objects shall not be used. Be careful not to damage the reflectors or to chip or to lift the cells. After excess RTV-40 has been removed, place the submodule in a box and allow it to cure for 48 hours at room temperature.

NOTE: Special RTV-40 will be procured by Engineering. This material shall be stored in the freezing compartment of the refrigerator. Check each container before using by mixing a small quantity with 1% of silicone T773 catalyst. If the mixture hardens in 20 minutes, the RTV-40 is satisfactory for use. Reject all material which does not harden within this period.

8.9 Electrical Interconnection of Solar Cells

a. Remove all traces of RTV-40 from the tinned area of the connector tab. Clean both the connector tab and the paralleling bus bar. Hold the tab in contact with the bus bar and solder in place.

b. Clean the area next to the solder joint thoroughly by swabbing with cotton swabs dipped in ethyl alcohol.

c. Insert the press-fit bushings into the predrilled holes on each end of the panel. Solder the special connectors on each end of the series string to the top stud of the bushing. Bond wire having the proper color to the edge of the stiffener. Leave sufficient slack so that the wire can be connected to the backside stud of the bushing. Remove the insulation with a hot wire stripper and solder the wire to the stud. Route the wire down the edge of the submodule to the spar beams. Lay the wire on the top side of the spot welded flange and insert the wire into the spring hold-down clamps. Identify the leads and install them in the cabling clamps carried on the spar beams.

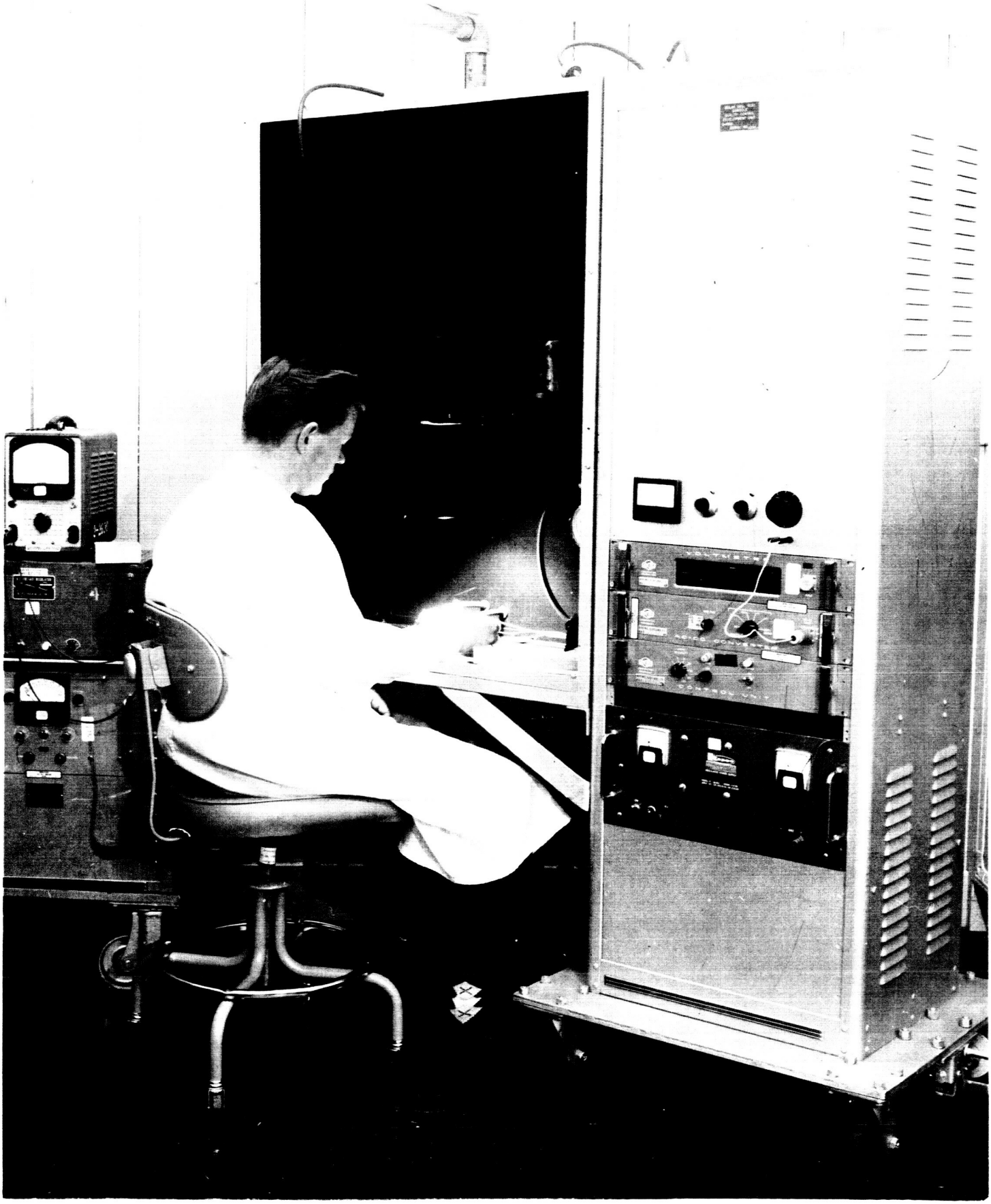


FIGURE 1 SOLAR CELL TEST CONSOLE
2A144843

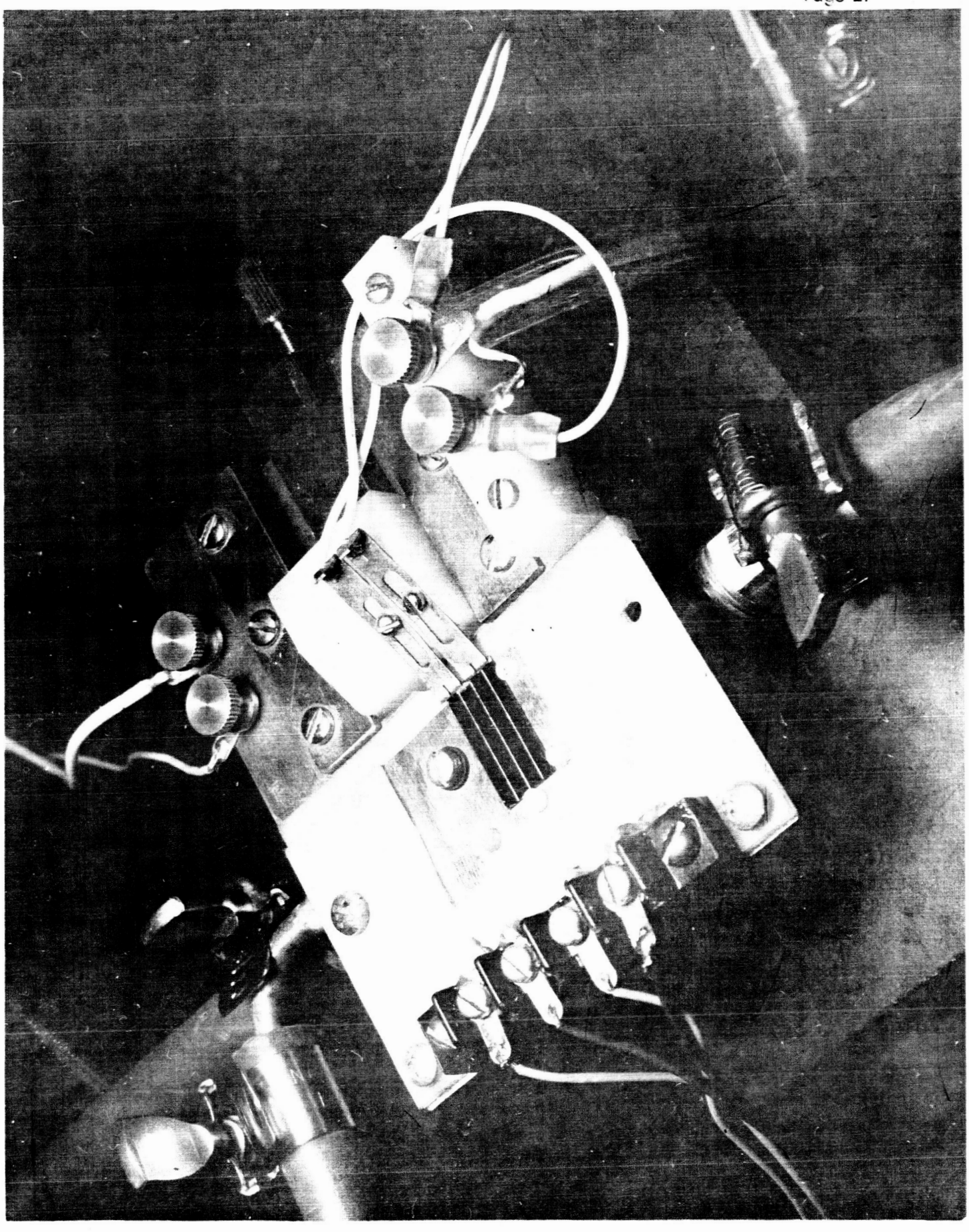


FIGURE 2 WATER COOLED SOLAR CELL TEST FIXTURE
2A144844

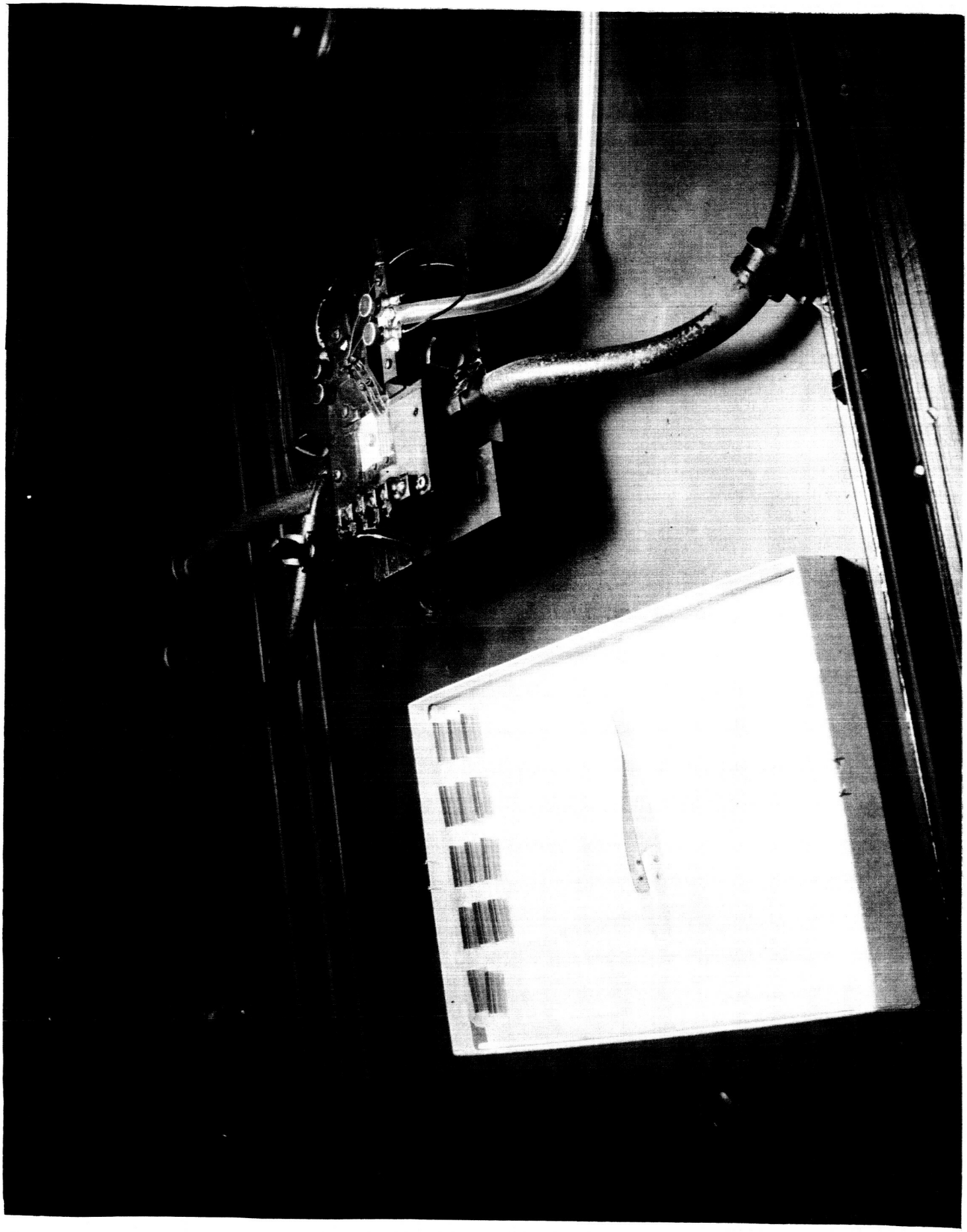


FIGURE 3 TEST OF SINGLE SOLAR CELL
2A153238

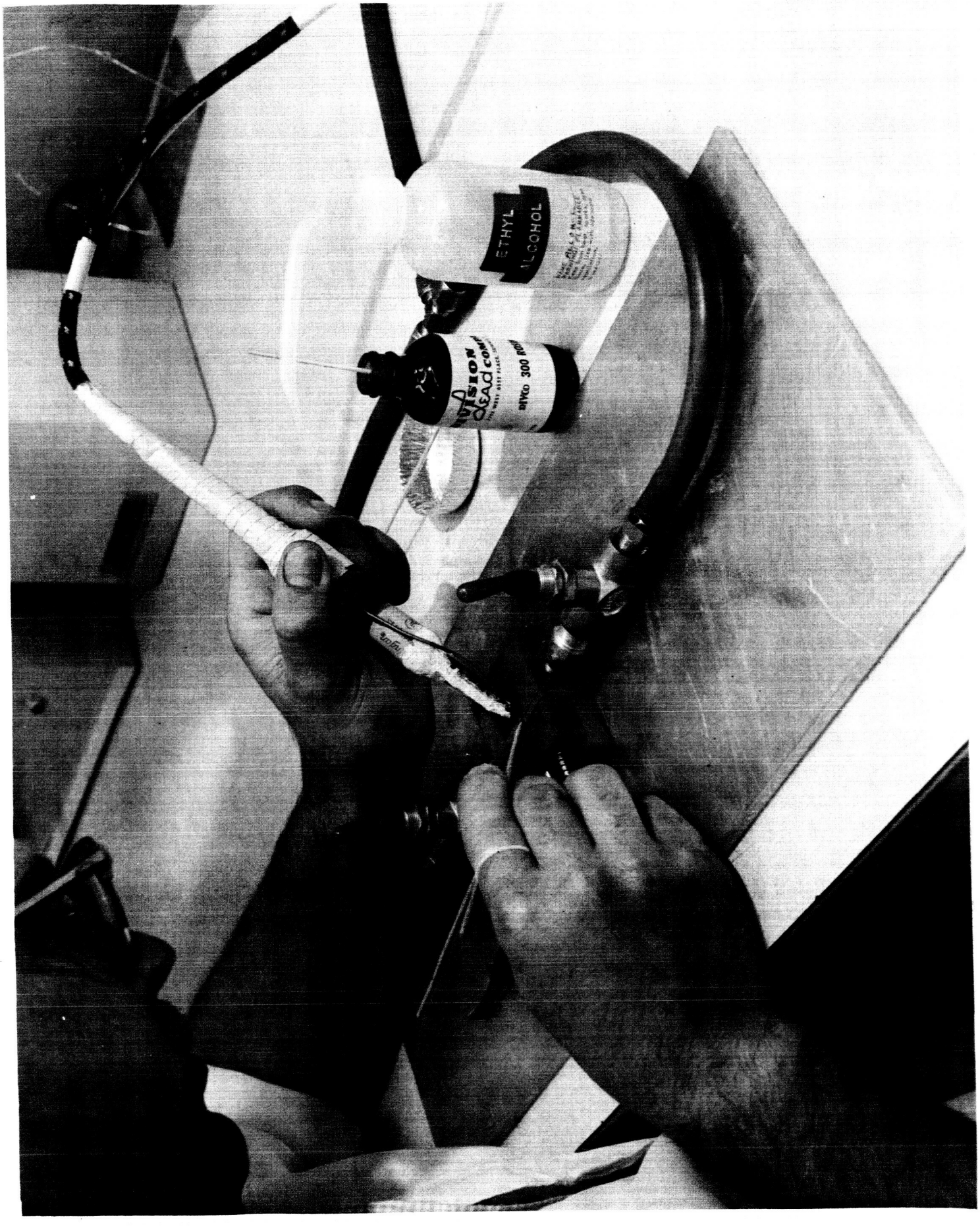


FIGURE 4 SOLDERING SOLAR CELL PAIRS
2A153236

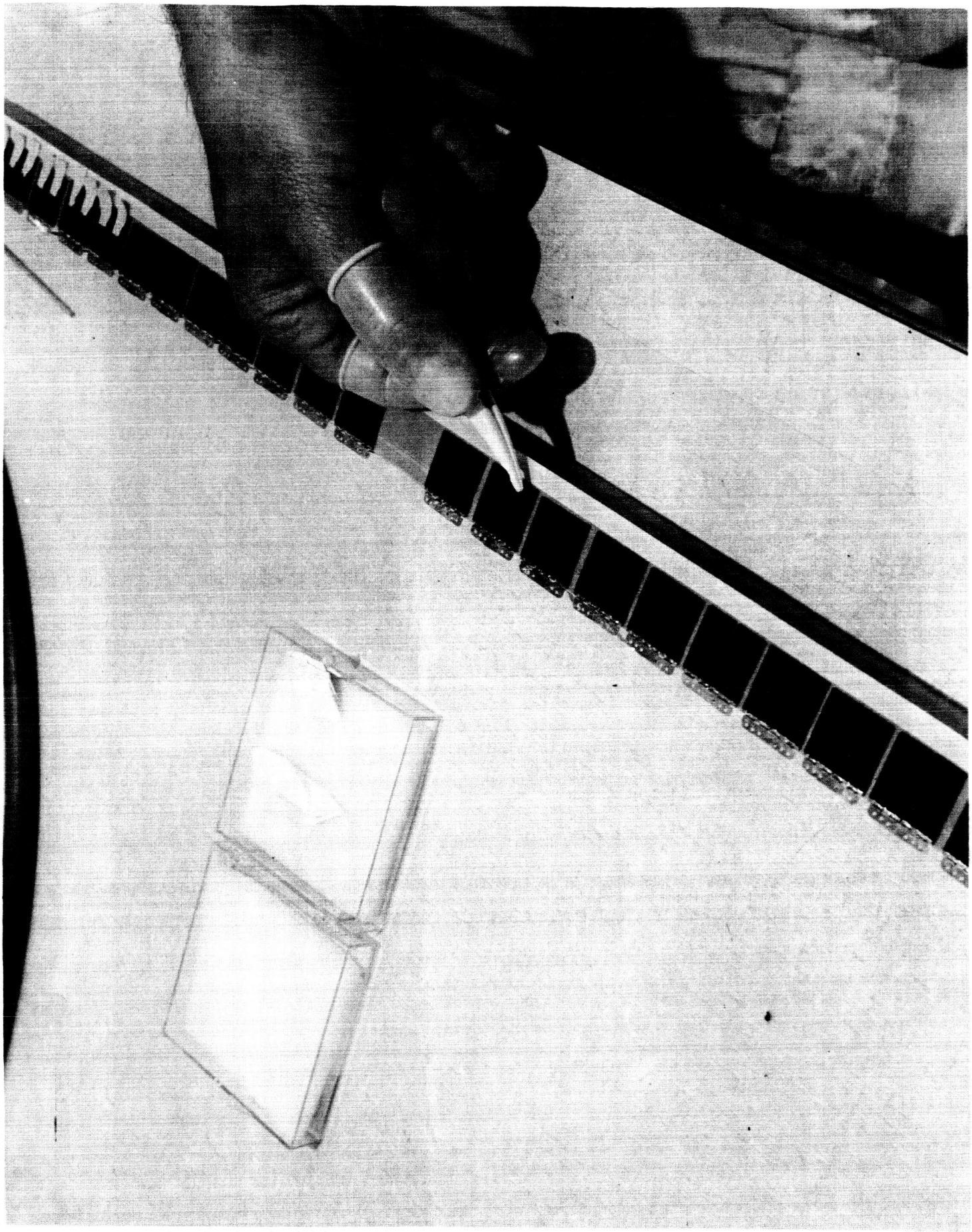


FIGURE 5 INSTALLING COVER GLASSES ON SOLAR CELLS
2AI53235

FIGURE 6 PAIR TESTING OF SOLAR CELLS
2A153233

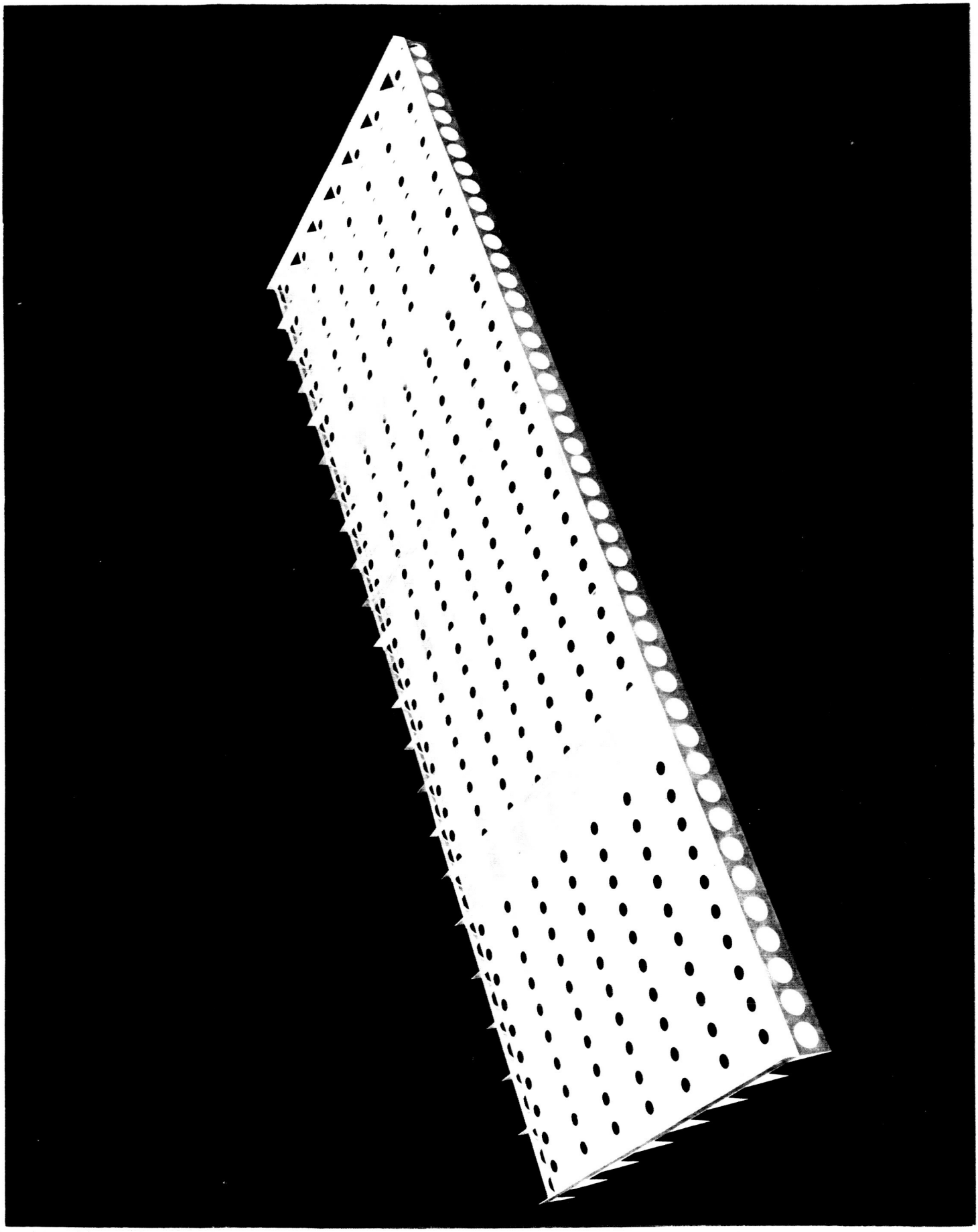


FIGURE 7 BACK SIDE OF CONCENTRATING SUBMODULE

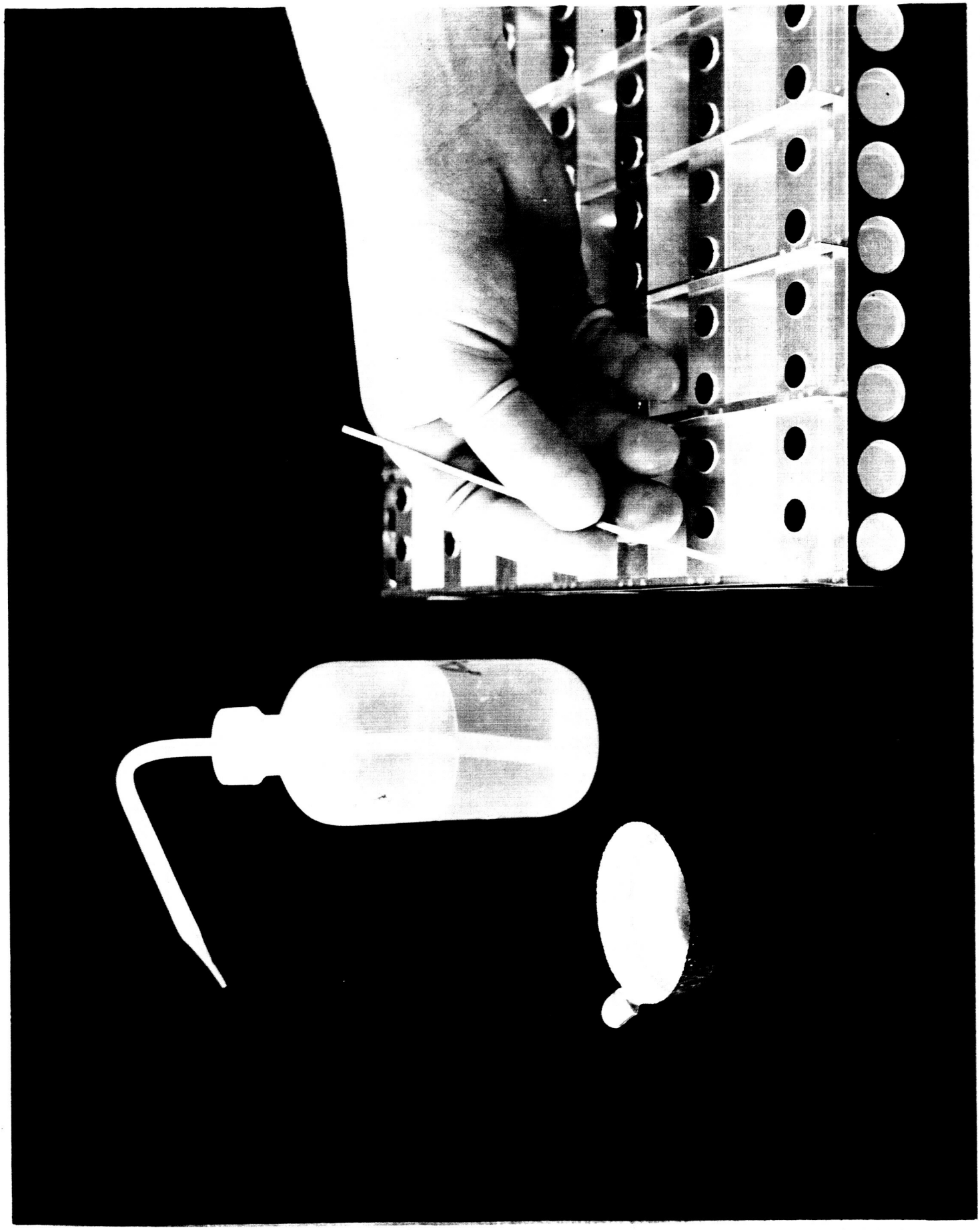


FIGURE 8 CLEANING ANGLE STIFFENERS

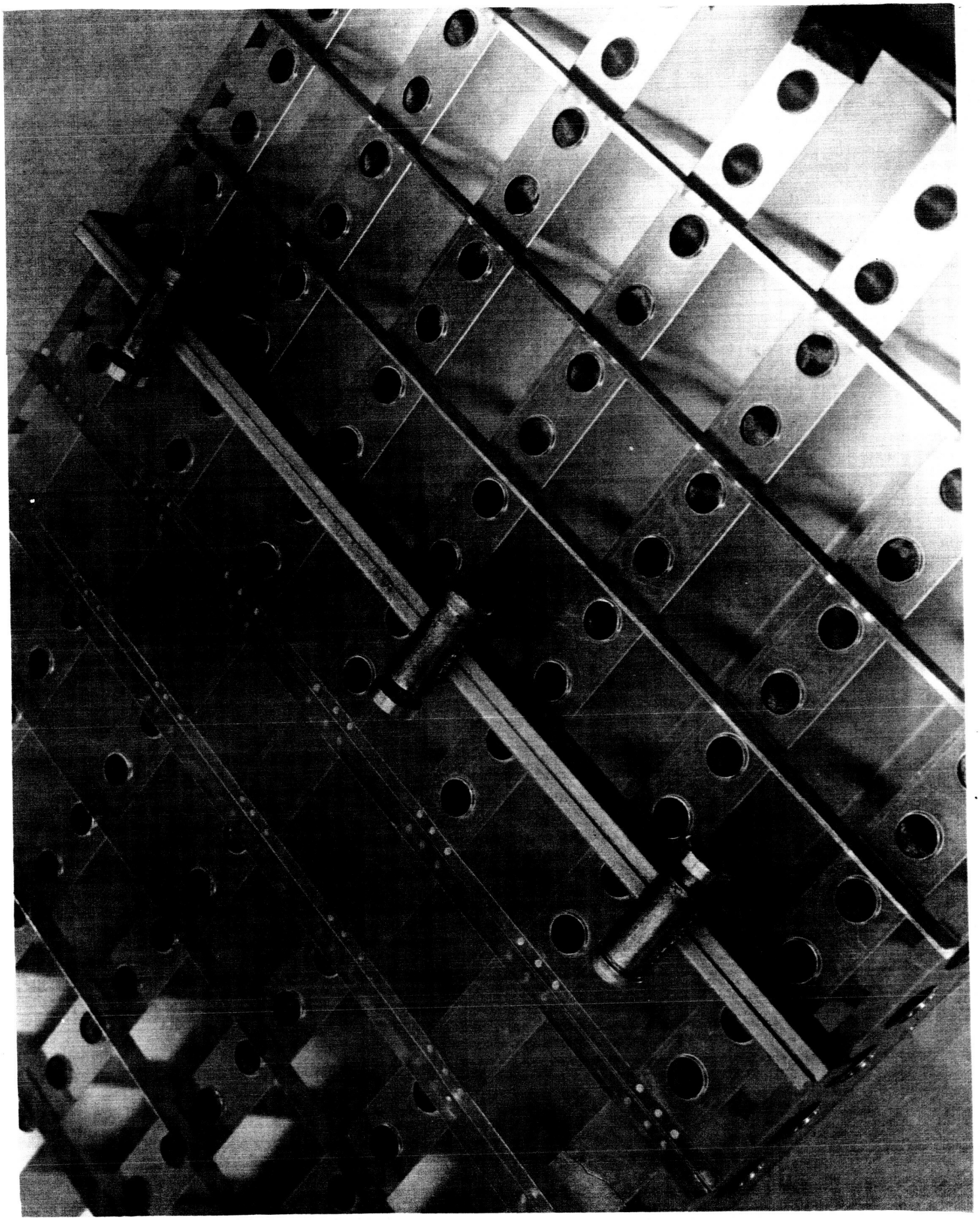


FIGURE 9 INSTALLING BUS BARS
2A15323!

FIGURE 10 FRONT SIDE OF CONCENTRATING SUBMODULE

FIGURE 11 CLEANING PANEL TROUGHS

FIGURE 12 APPLYING THE INSULATING TAPE TO TROUGH

FIGURE 13 FRONT SIDE OF PANEL AFTER INSTALLATION OF TAPE AND GROMMETS
2A153232

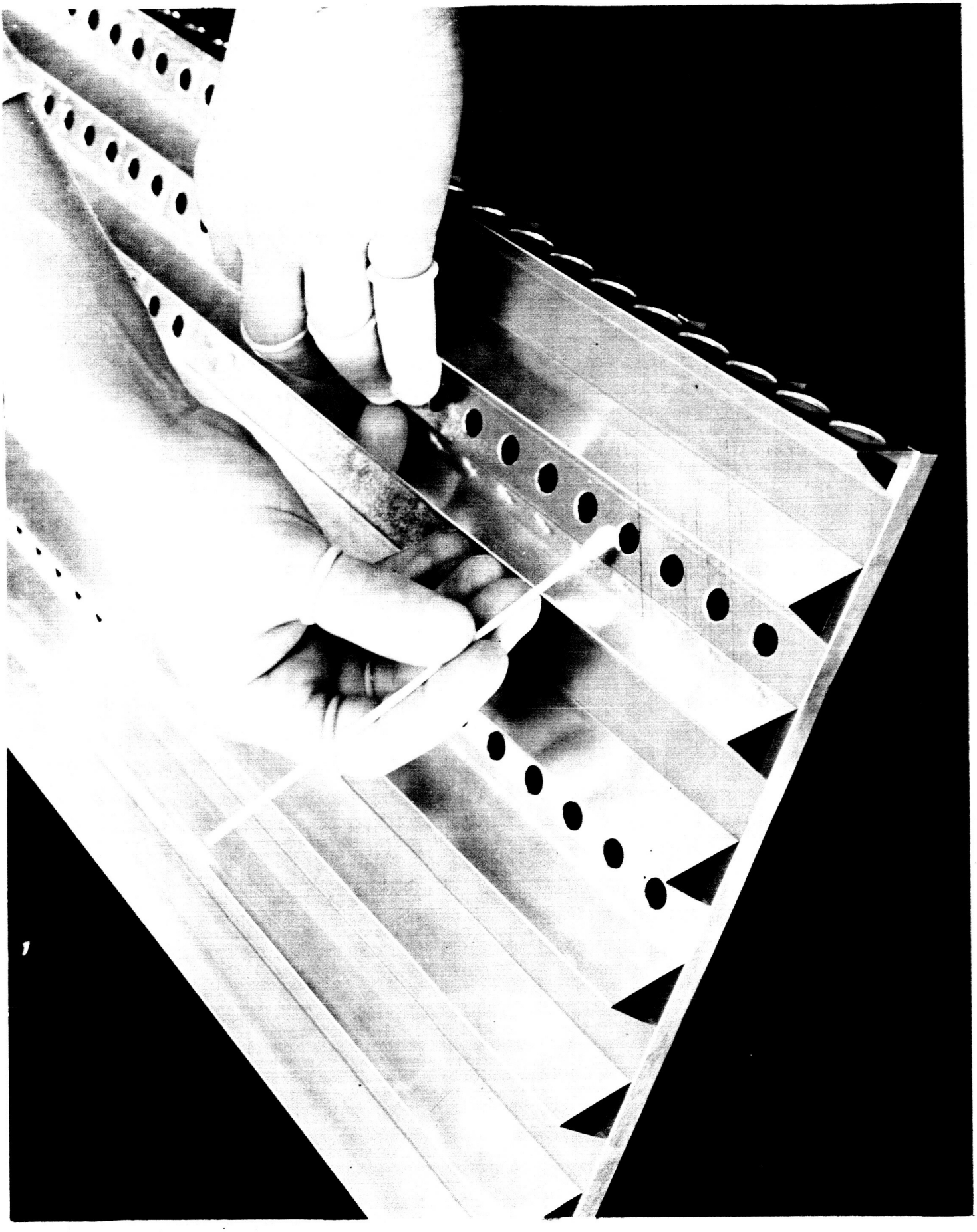


FIGURE 14 CLEANING INSULATING TAPE PRIOR TO PRIMING

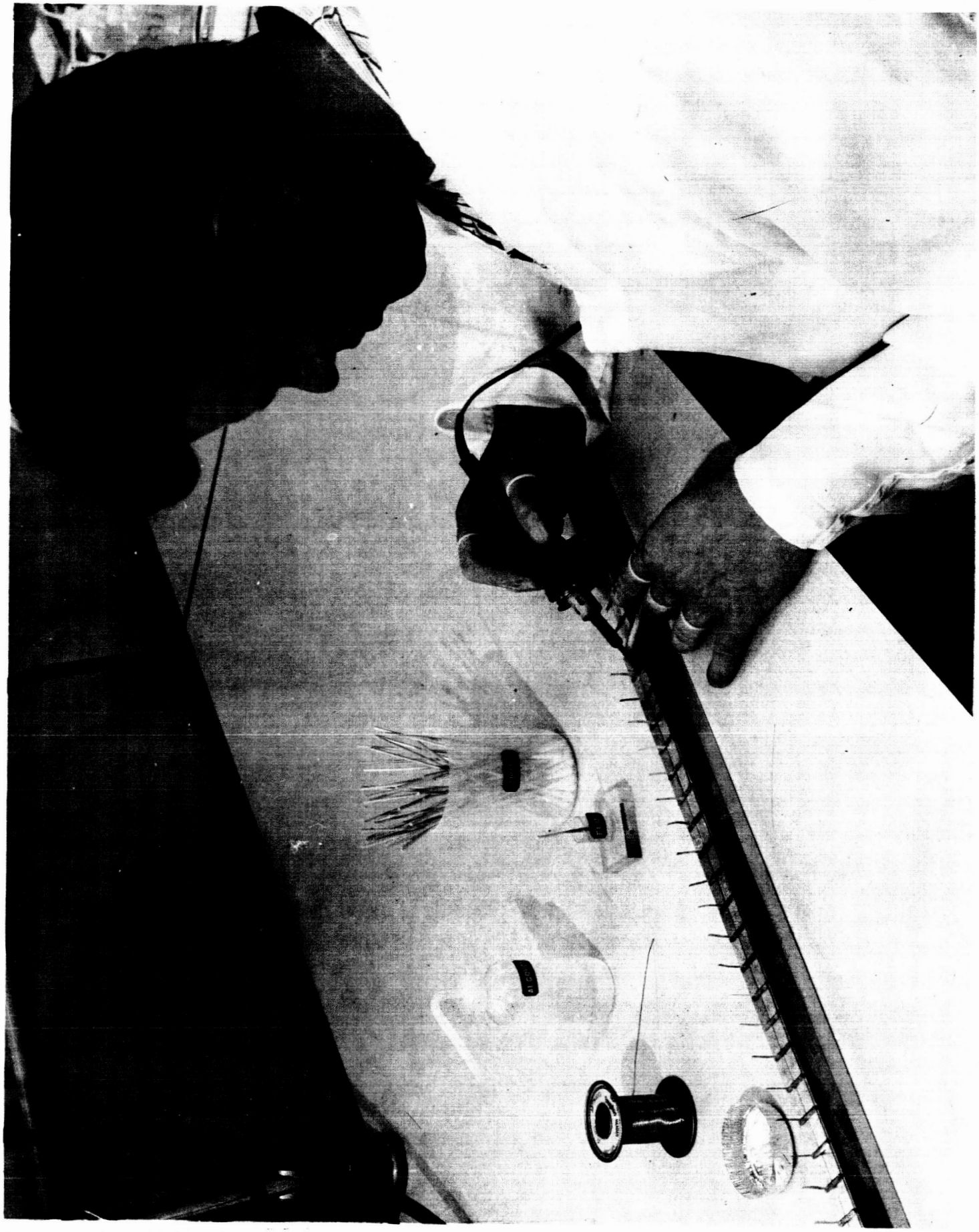


FIGURE 15 SOLDERING NEGATIVE SIDE OF SOLAR CELLS
2A144871

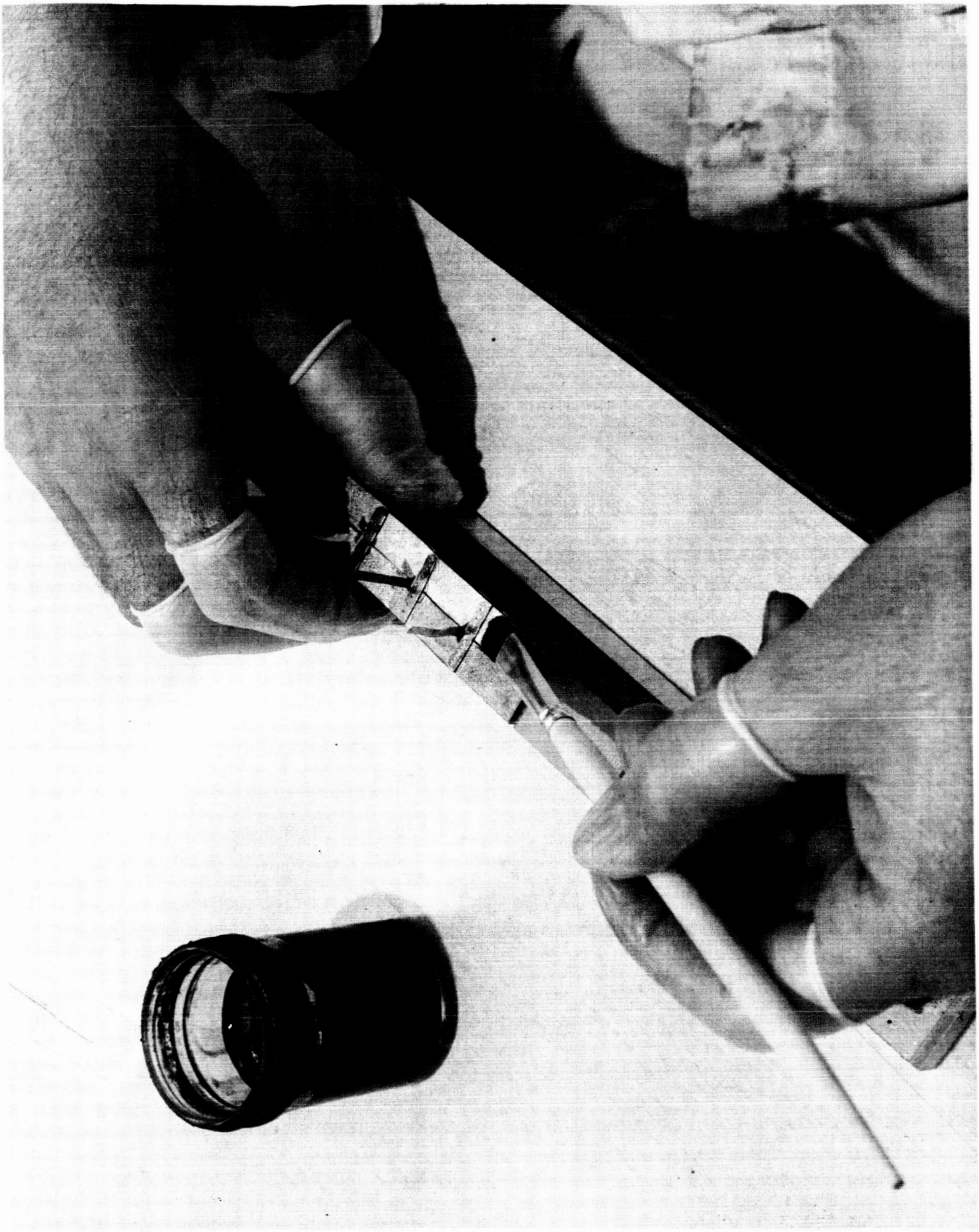


FIGURE 16 PRIMING SOLAR CELLS
2A153234

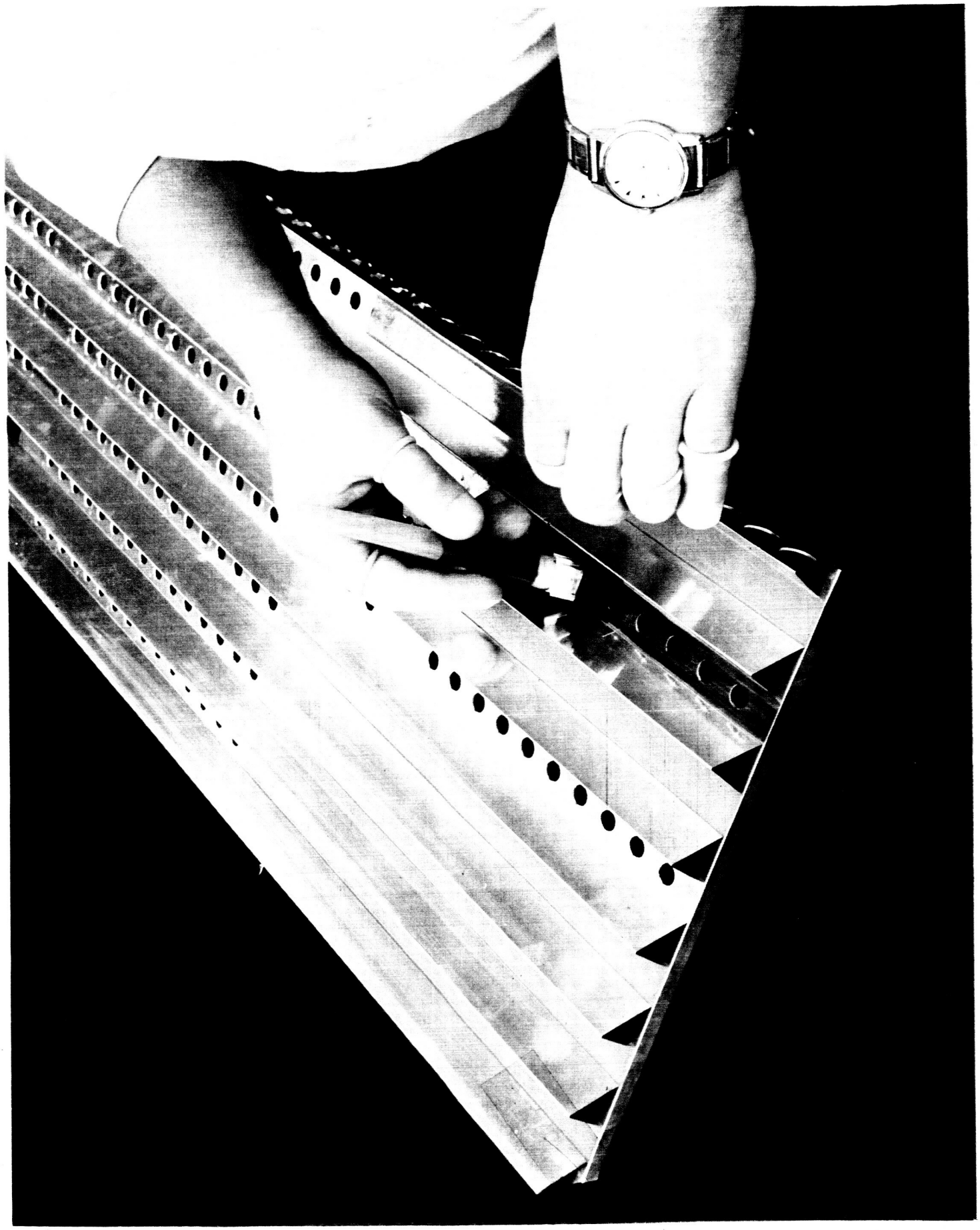


FIGURE 17 APPLYING PRIMER TO TAPE

FIGURE 18 RTV-40, THERMOLITE-12, SCALE AND MIXING TOOLS

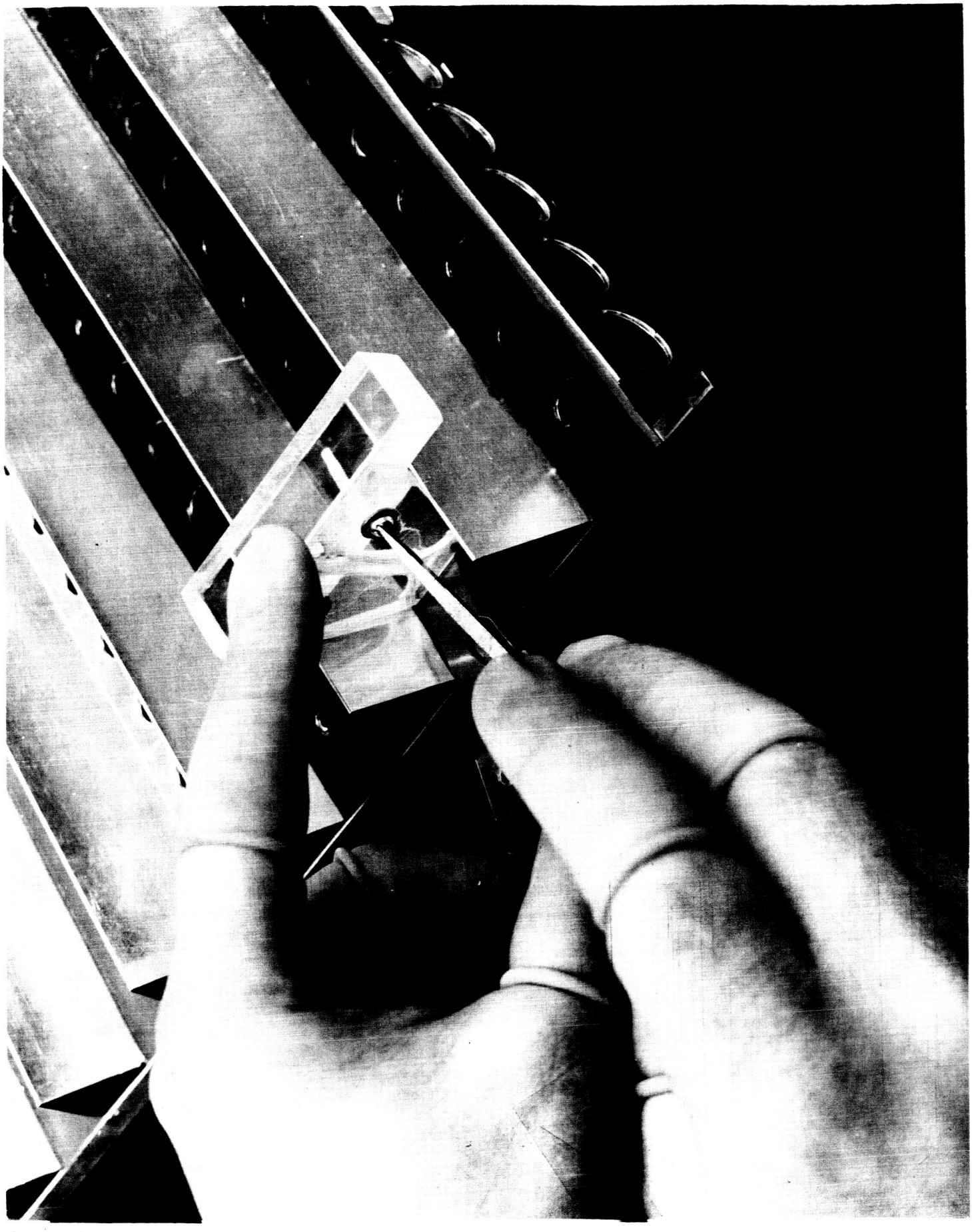


FIGURE 19 ADJUSTING APPLICATOR TO LAY A 5 MIL THICKNESS OF RTV-40 IN TROUGH

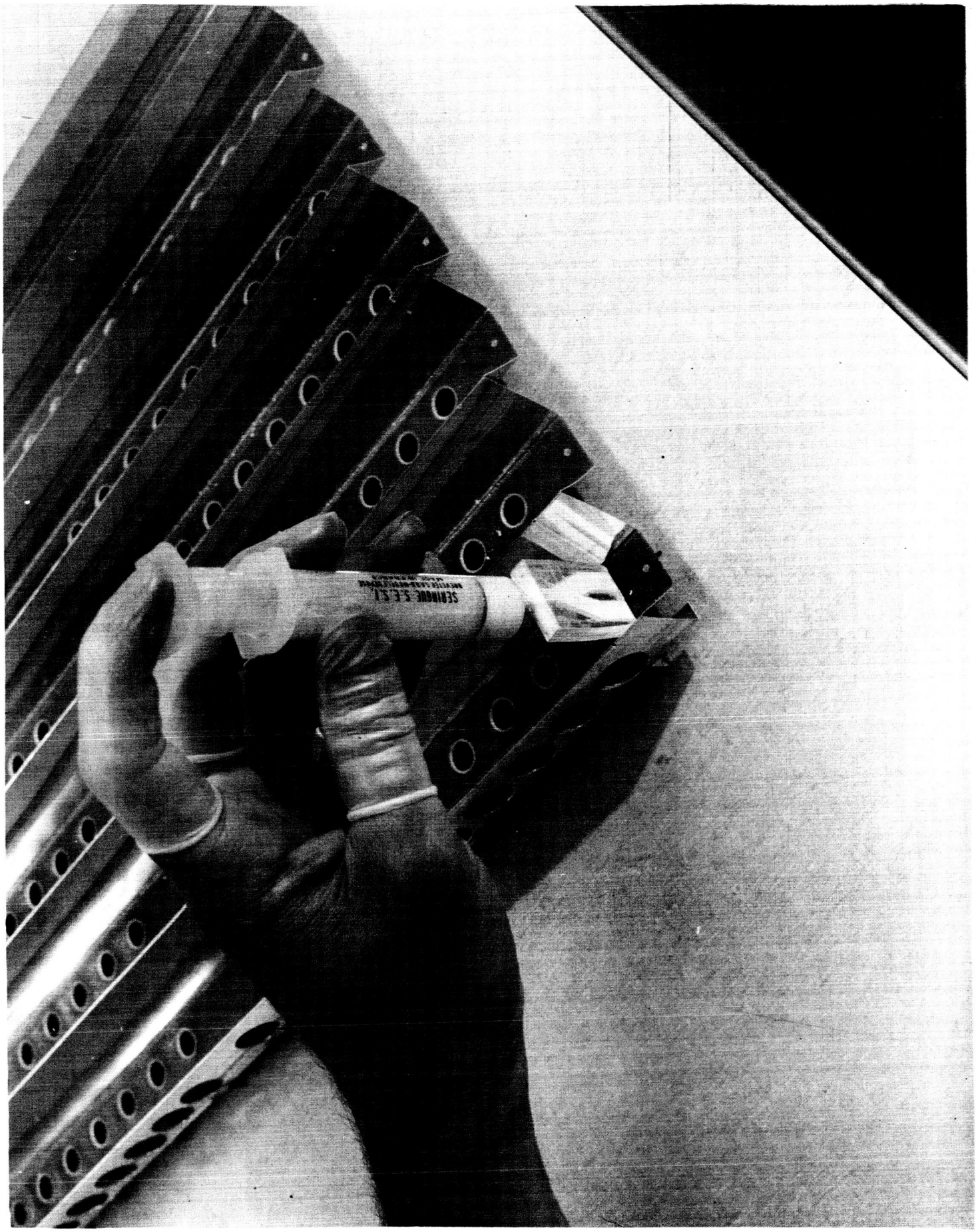


FIGURE 20 SPREADING RTV-40 IN TROUGH
2AI53237

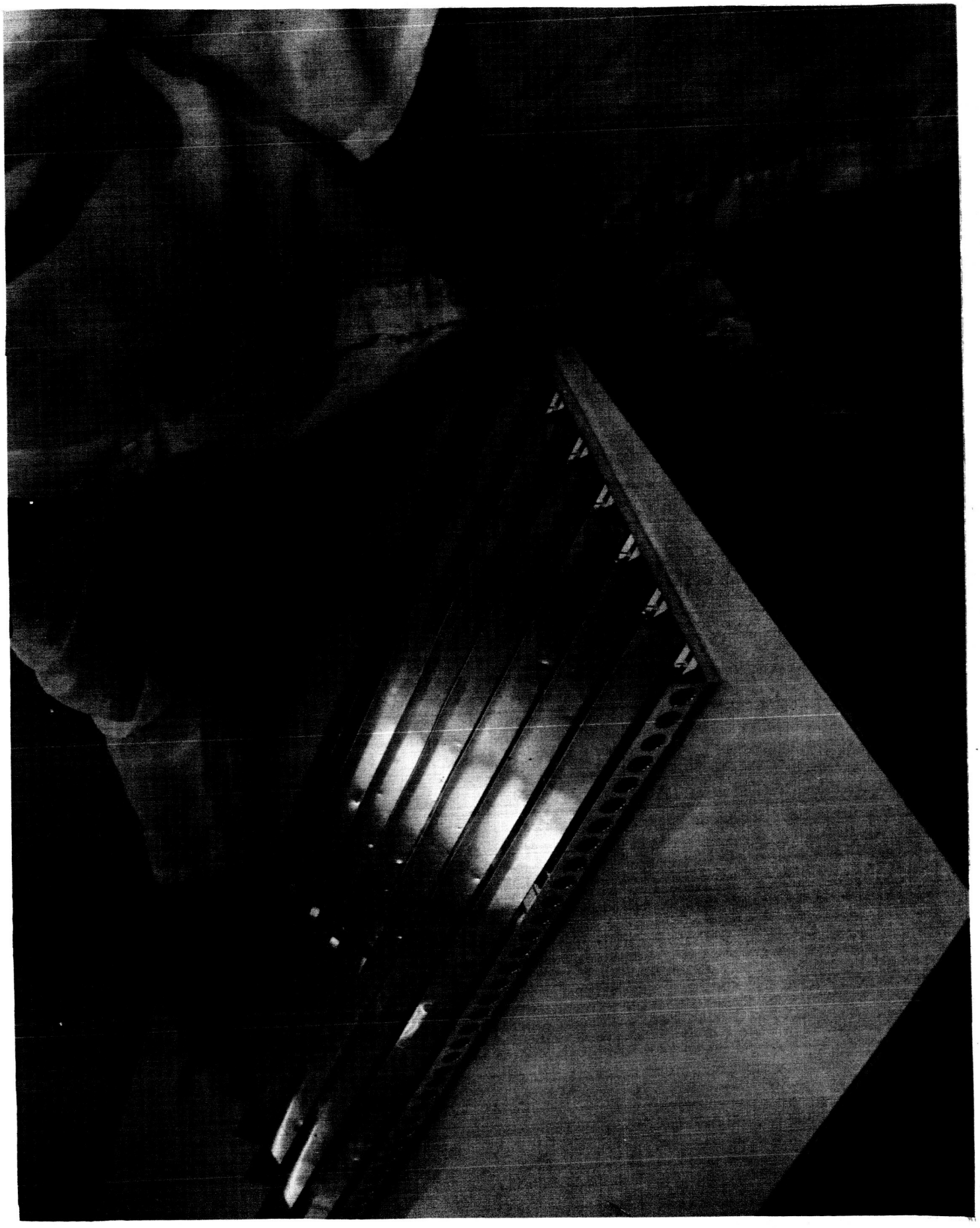


FIGURE 21 LAYING CELLS IN THE TROUGH
2AI53230

FIGURE 22 WEIGHTS HOLDING SOLAR CELLS IN TROUGH WHILE CURING

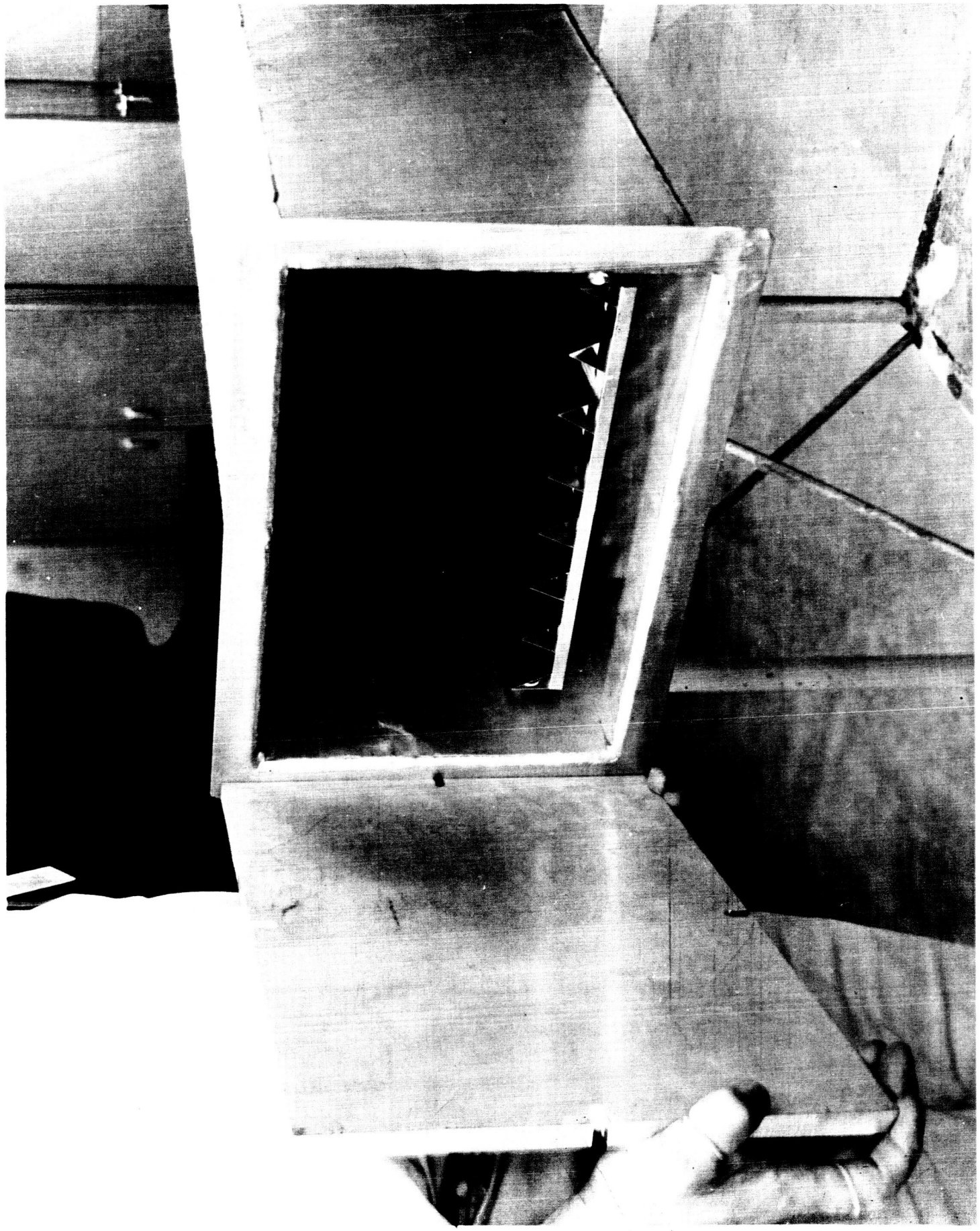


FIGURE 23 ASSEMBLED PANEL PLACED IN VACUUM CHAMBER

FIGURE 24 CLEANING EXCESS RTV-40 FROM SOLAR CELLS

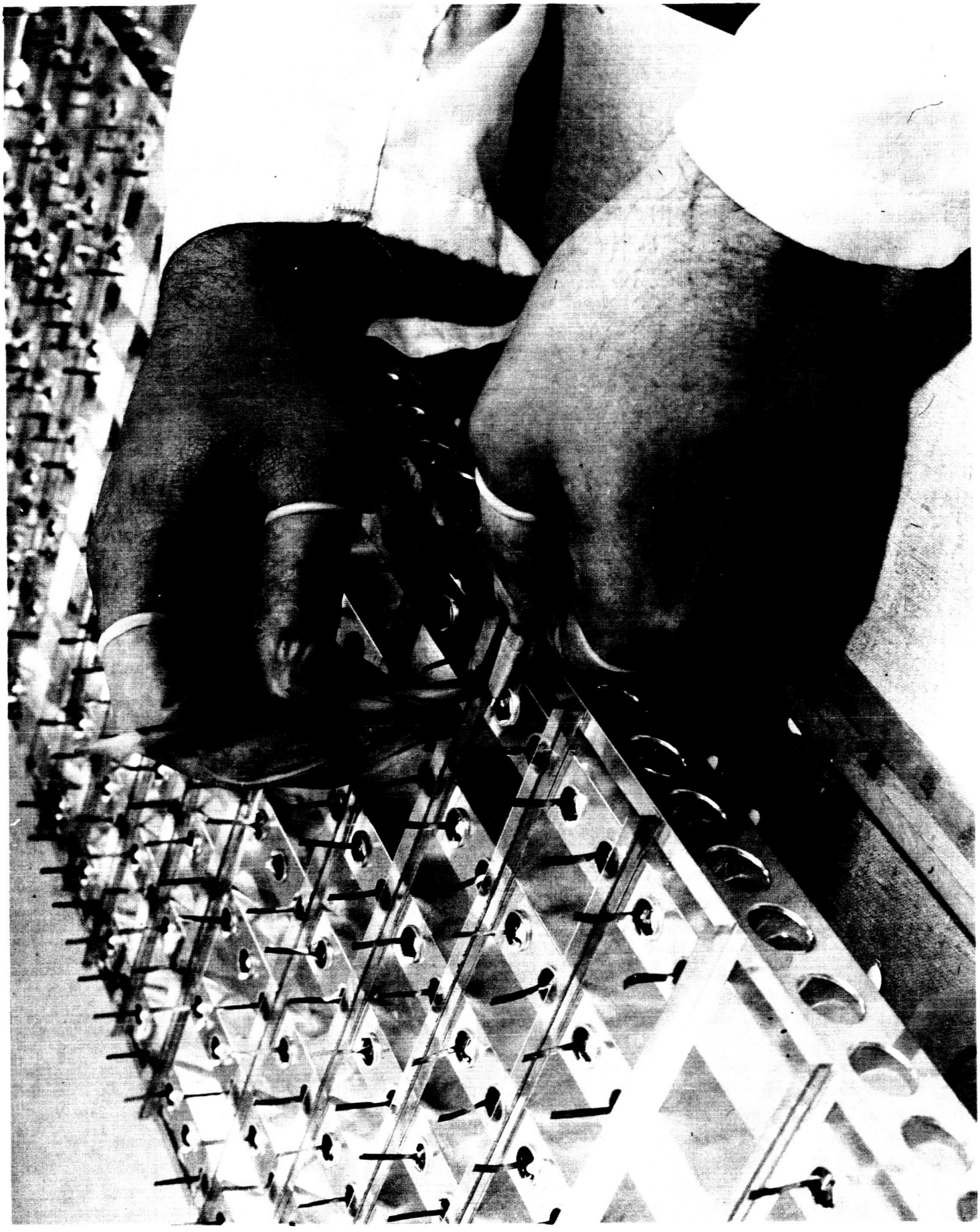


FIGURE 25 FORMING CONNECTOR TABS
2A144874

FIGURE 26 SOLDERING CONNECTOR TABS TO BUS BARS
2A144875